RESEARCH HIGHLIGHT

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REMOTE MONITORING AND CONTROL OF ON-SITE WASTEWATER TREATMENT, RECYCLING, AND REUSE SYSTEMS

INTRODUCTION

On-site wastewater treatment systems—conventional and more sophisticated—are usually installed to service properties in rural areas, small communities, or suburban developments where central sewers are unavailable. These systems serve 30 to 40 per cent of the population of Canada. On-site systems, when appropriately planned, designed, installed, monitored, operated, and maintained, provide cost-effective alternatives to central collection and treatment systems. Presently in Canada few on-site systems are used for reuse—the majority dispose of treated wastewater through subsurface discharge. Systems utilized with a reuse component will require even more stringent monitoring and maintenance.

On-site wastewater treatment, recycling and reuse systems have been used or proposed:

- in urban situations where extension of existing services was prohibitively expensive, or a lot size and site conditions could not accommodate a conventional on-site system;
- for non-urban situations where site or soil conditions made use of conventional systems or central systems impractical or too expensive;
- in remote military installations in the North; and
- in northern communities where the only practical servicing alternative has been truck-hauled water supply and wastewater disposal.

Even the simplest of these systems, if improperly used and maintained, can fail, and more complex systems cannot be expected to operate reliably and effectively without periodic or continuous monitoring and control. Malfunctioning of on-site systems in non-urban areas has led to installation of expensive collection and treatment systems in order to correct or prevent contamination of adjacent land areas, groundwater or surface waters, with associated threats to health and the environment. Results of malfunction of a recycling and reuse system, in the absence of effective alarms, fail-safe controls, and immediate response, can present more immediate concerns in terms of health and inconvenience.

Examples of a variety of sensing, recording, monitoring, and communication technologies that have been applied to such systems have been described in a variety of papers, reports, and commercial publications. But no single non-commercial document exists to guide planners, designers, managers, and regulators as to the capabilities, limitations, opportunities, and benefits associated with options for remote monitoring and control of systems for on-site wastewater treatment, recycling, and reuse. This research was undertaken to address that need.

RESEARCH

The scope of the research included consideration of:

- Systems and system components currently in use, and alternatives presented by new and emerging technologies.
- Systems appropriate to a single on-site wastewater system, and those suitable for a network of many on-site units.
- Systems appropriate for a range of systems from simple passive conventional on-site systems to complex recycling and re-use systems.

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HOME TO CANADIANS

The report first provides an overview of on-site wastewater treatment, recycling and reuse systems, including a discussion of basic concepts, management principles, and the role of, and examples of, remote monitoring and control. It continues with a review of system operating and water quality parameters that are, or could be, the subject of remote monitoring and control. This discussion is followed by case studies drawn from recent publications, the internet, and commercial information. Appendices provide additional information about products and product sources.

OVERVIEW

Traditional on-site systems have no mechanical or electrical components, provide pre-treatment in a septic tank, and rely on native soil to provide further treatment before the effluent reaches groundwater or surface water. They include no controls; monitoring is limited to periodic checking of solids and scum levels in the septic tank; and maintenance is normally limited to water conservation, care in the materials that are included in the wastewater, and periodic pumping of the septic tank.

On-site systems for more difficult site conditions may require additional maintenance, monitoring, and control. They can include pumps and additional treatment components, such as mounds or media filters, include more sophisticated systems for subsurface disposal, or use surface disposal. System designs may be required to address specific surface water or groundwater quality concerns, which can include bacteria, nitrates, and phosphorus. Effluents from some sources may require additional treatment, e.g. removal of oils and grease from restaurant wastes.

In areas of chronic water shortage or prohibitive infrastructure costs, wastewater reuse is gaining acceptance as a potential option. Wastewater recycling and reuse can be described by the following terms: Wastewater ***reclamation*** is the treatment or processing of wastewater to make it suitable for recycling and reuse. Wastewater ***recycling*** is the return of reclaimed wastewater to be used again for the purpose that generated the wastewater, e.g., recycling of all household black water (from a toilet, urinal or bidet) and grey water (from all other sources) for all non-potable uses. Wastewater ***reuse*** refers to the use of reclaimed water for a purpose other than its original use, e.g., the reuse of grey water for toilet flushing or irrigation.

Planning and design of any on-site recycling or reuse system installation should recognize both the complexity of the system and the potential consequences of system malfunction, and should assume that the system will require monitoring and control, that the system will be designed to be managed, and that an appropriate management capability will be in place. A summary is provided of management arrangements for 11 recycling/reuse systems in Canada and the United States.

On-line monitoring is currently impossible, nor cost-effective, for many water quality parameters, including microbiology, conductivity, and colour. Detailed cost information is provided later in the report.

For a basic conventional on-site system, indicators of system performance that might be remotely monitored are water use, and levels of sludge and scum accumulation in the septic tank. Remote control of such systems is unlikely.

Examples of remote monitoring and control of on-site wastewater treatment, recycling, and reuse systems are provided, and references that discuss and provide examples of remote monitoring and control systems are reviewed.

REMOTE MONITORING AND CONTROL

Even the simplest of on-site systems requires some form of monitoring, and requires response to the information obtained as a result of that monitoring. Examples might range from periodic visual checks of sludge accumulation in a septic tank, resulting in pumping at appropriate intervals, to remote monitoring and appropriate control of many systems that include pumps and other mechanical components.

The objective of monitoring might be:

- to provide information for system control or management, or
- to display and/or record overall system performance for long-term operation and maintenance, and regulatory oversight.

Following is a summary of the range of monitoring options that might provide the information that generates a management response:

- Some information, such as water level, might be polled periodically, or recorded continuously.
- Periodic measurements, such as meter readings, could be obtained manually, or recorded automatically.
- Records obtained either manually or automatically could be recorded on site, or
- automatically recorded information could be remotely accessed.

Current control panel capabilities range from simple on-off alarm panels using only float settings and other common elements such as circuit breakers, control switches, and pump control relays, to more elaborate panels that include programmable timers, elapsed time meters, event counters, data acquisition modules, and programmer and telemetry interfaces.

The basic concepts and technologies involved in remote monitoring and control are illustrated by a figure that shows a generalized Supervisory Control and Data Acquisition (SCADA)

system with three remote stations controlled by a single master terminal, which is the basis for brief overview of the measurement and control functions. This introduction by detailed discussion of data acquisition, transmission, and management is provided in the following sub-sections.

Controls include features of the system that actively or passively dictate or "control" the operation of a system. Controls have developed from simple float switches to programmable timers and improved active mechanical controls. Simplest controls include:

- flow controls, e.g., valve, weir, or orifice,
- electrical controls, e.g., a float switch turning a pump or blower on or off, and
- alarms, e.g., a float switch connected to a light (visual) or buzzer or bell (audible).

Controls can be subdivided into hydraulic and mechanical controls, and further classified as:

- Fixed controls: e.g. built-in hydraulic capacity of a septic tank, piping and dispersal field.
- Passive controls: normally fixed but permit adjustment, e.g., valves that permit diversion from one dispersal field to another, or adjustable weir devices that can control flow distribution in on-site dispersal systems.
- Automatic mechanical controls: operate mechanically during the normal functioning of a system, e.g., float valves, siphons or tipping buckets to divert, split, or control dosing.

WASTEWATER MANAGEMENT PARAMETERS

This section considers sensors designed to monitor physical parameters (water level, flow, water demand (cumulative flow), and temperature), and the following water quality parameters: Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), pH, Suspended Solids, Turbidity, Nitrogen, Phosphorus, and Microbiological Contaminants.

An appendix summarizes sources of sensors for individual parameters, and websites that provide very complete lists of products that are amenable to remote monitoring and control of on-site wastewater systems. Examples of the application of some of these and other sensors are provided by the case studies in the final section of the report.

Price ranges for each technology are provided in the text and an appendix. It is evident that the costs cited for some of these technologies would make them unavailable for the systems considered in this report.

CASE STUDIES

This section presents 12 case studies that represent systems that are appropriate to a single on-site wastewater system, and those that can be integrated into a network of on-site units, both conventional and those designed to recycle or reuse the treated effluent.

Each example introduces the specific situation to which it applies, followed by a brief description of the technology involved in its design. Where possible, the costs and benefits of each technology are briefly discussed. More information about these systems can be found in the listed references.

System	Remote Monitoring	Remote Control	Information Management
Carmody Waste Recording Service	X		X
Creative Communities Research	X	X	X
Hill Murray Associates, Inc.	X	X	X
Hydroxyl Systems Inc.	X	X	X
MicroSepTec	X	X	X
Orenco Systems (VeriComm)	X	X	X
QuadTech, LLC	X	X	X
SJE-Rhombus	X	X	X
Stephens Consulting Services	X	X	X
Waterloo Biofilter Systems Inc.	X	X	X
Worldstone Inc.	X		X
Zabel Environmental Technology	X	X	

Each case study illustrates one or more of the following functions:

- Remote monitoring.
- Remote control.
- Information management, based on information generated by a remote monitoring and control system.

The management systems reviewed are those that are known to involve remote monitoring of on-site wastewater systems; other on-site management systems or software that do not rely on remote monitoring are referenced.

The final section of the research report presents the 12 case studies listed in the preceding table, including a brief description of the technology involved in the design of the system and the specific situation to which it applies.

IMPLICATIONS FOR THE HOUSING INDUSTRY

The end product of this research was a document to guide planners, designers, managers and regulators as to the capabilities, limitations, opportunities and benefits associated with options for remote monitoring and control of systems for on-site wastewater treatment, recycling and reuse. The appendices include particularly useful information on costing and specifications for online sensors and analyzers, contact information for companies that manufacture sensors and analyzers and a chart indicating the products that each manufacturer sells. The case studies provide guidance as to how particular systems work and under what circumstances. This knowledge can be used to help develop new monitoring and control systems for on-site wastewater management.

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